Space constancy around the time of a saccade for intransient stimuli

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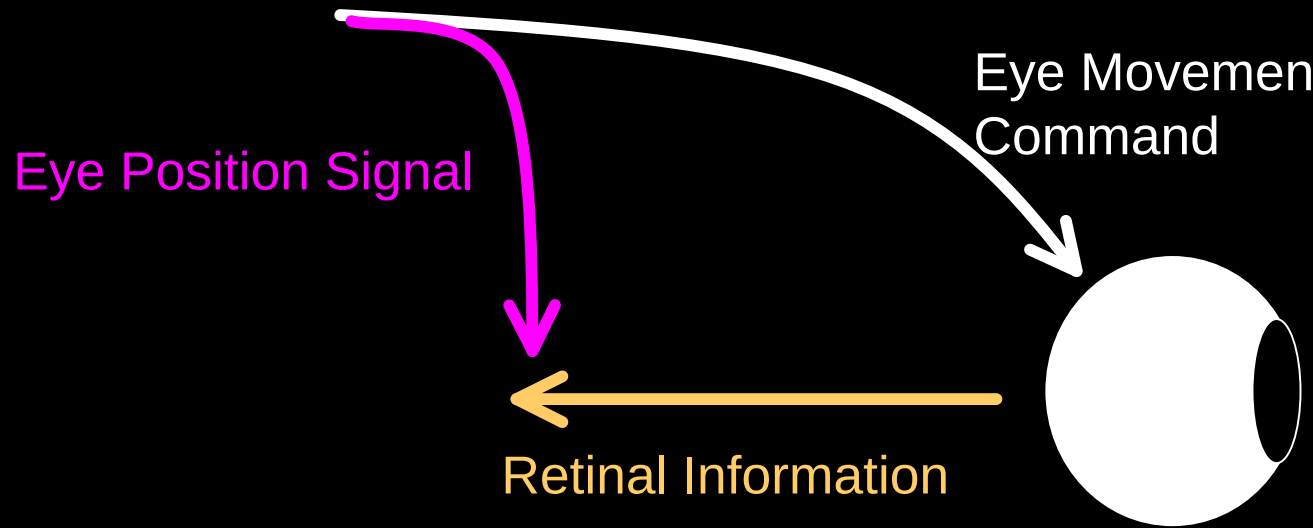
Perceptual space constancy

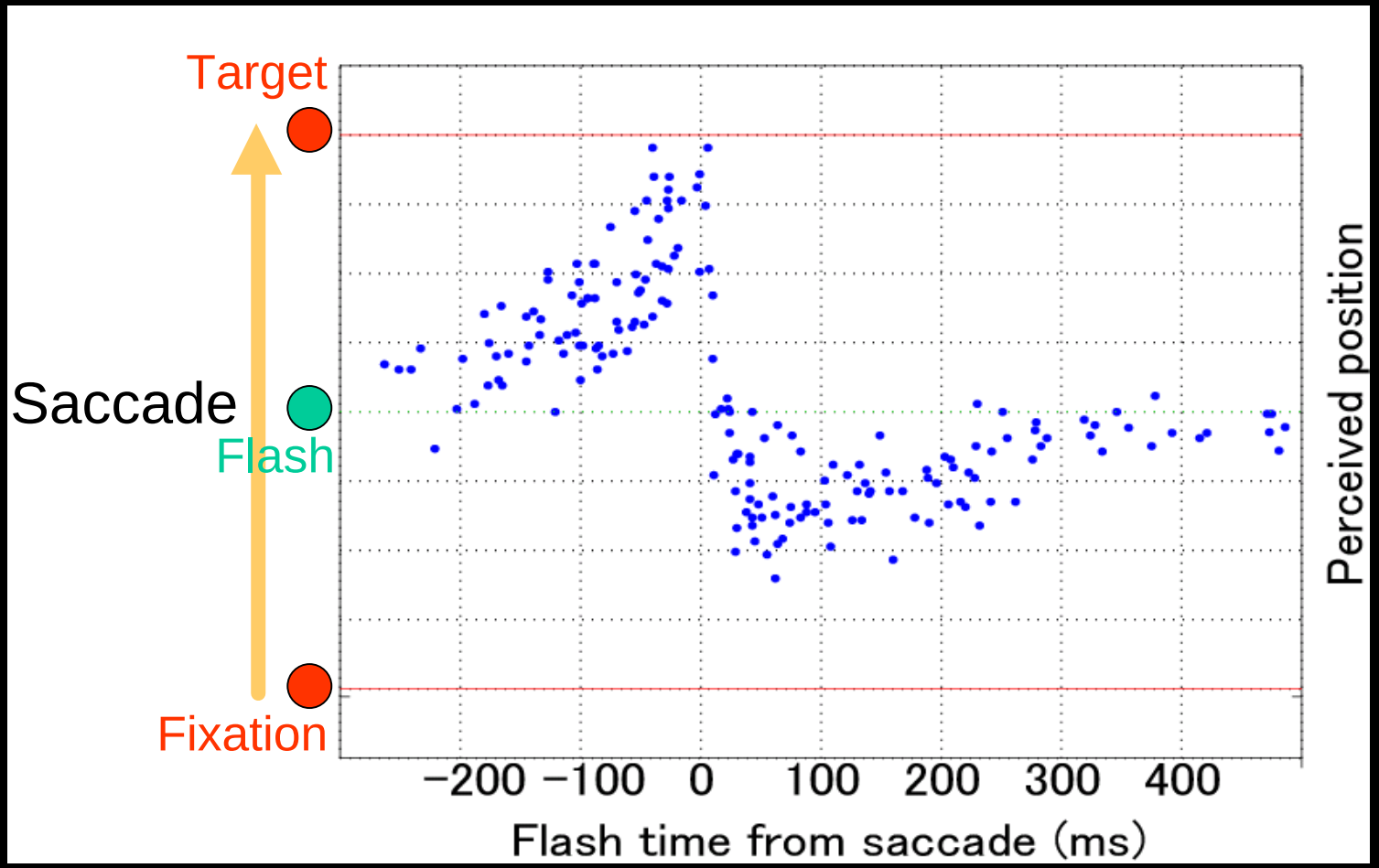
Human observers frequently make eye movements to see surrounding environments with the central area of the retina. Although the eye movements shift the location of stationary objects on the retina, the observers don't normally perceive the displacement of the objects.

A widely-accepted account of this compensation is the cancellation theory.
(Holst & Mittelstaedt, 1950; Holst, 1954; Sperry, 1950)



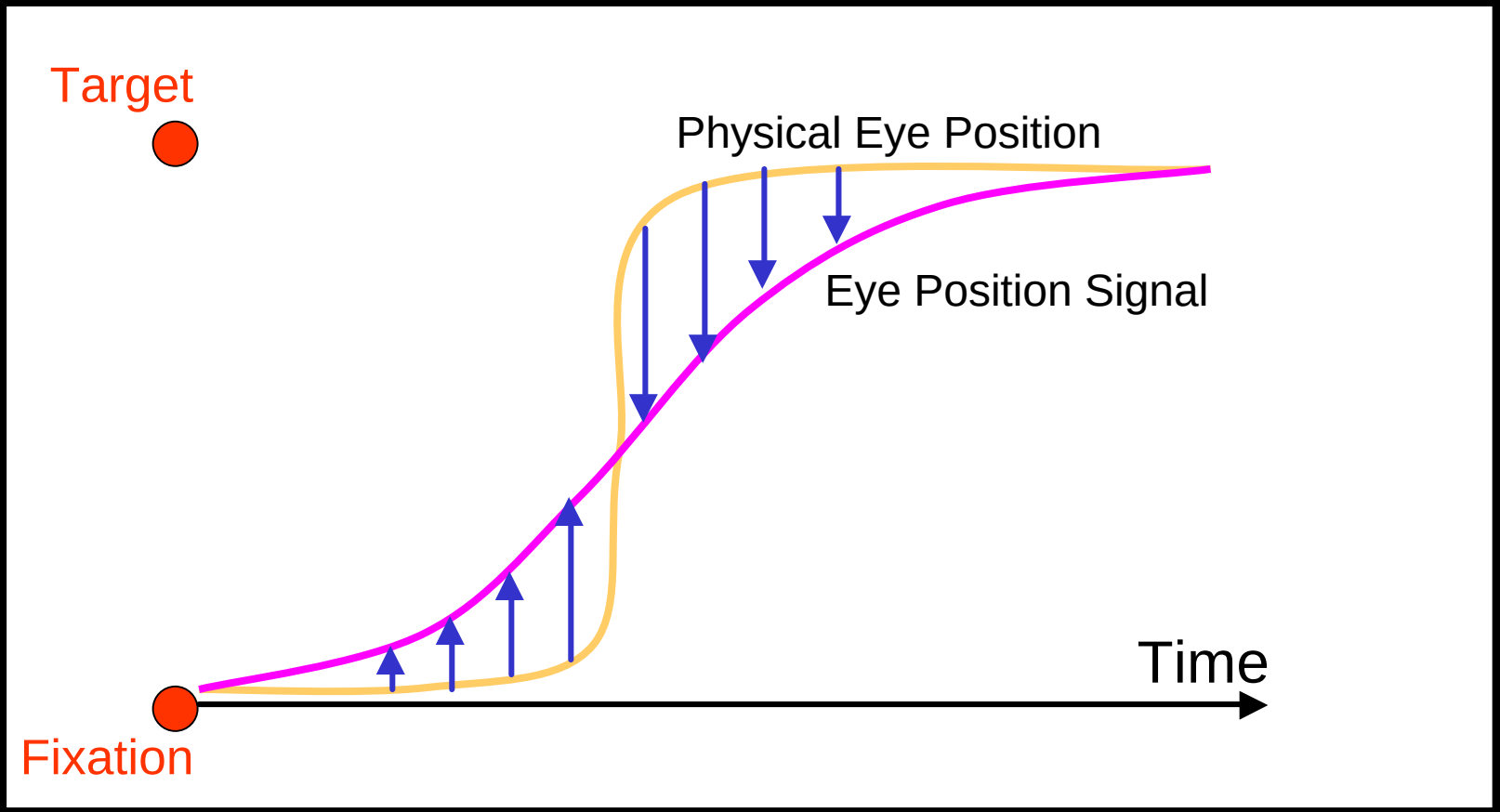
Mislocalization around the time of a saccade

Around the time of a saccade,
a flash stimulus is systematically mislocalized.
(Honda, 1990)



Conventional account of the mislocalization

Conventionally, the mislocalization is explained by the mismatch of physical eye position and internal eye position signal.
(Matin, 1968; Mateef, 1978; Honda,1990)



Space constancy measured with single flashes

Perisaccadic space constancy has been studied by mainly using single flashes.

However

A flash stimulus should not be regarded as a general probe for perceptual localization, since it's often mislocalized.

(e.g., Metzger 1932, Nijhawan 1994; Whitney & Cavanagh, 2000

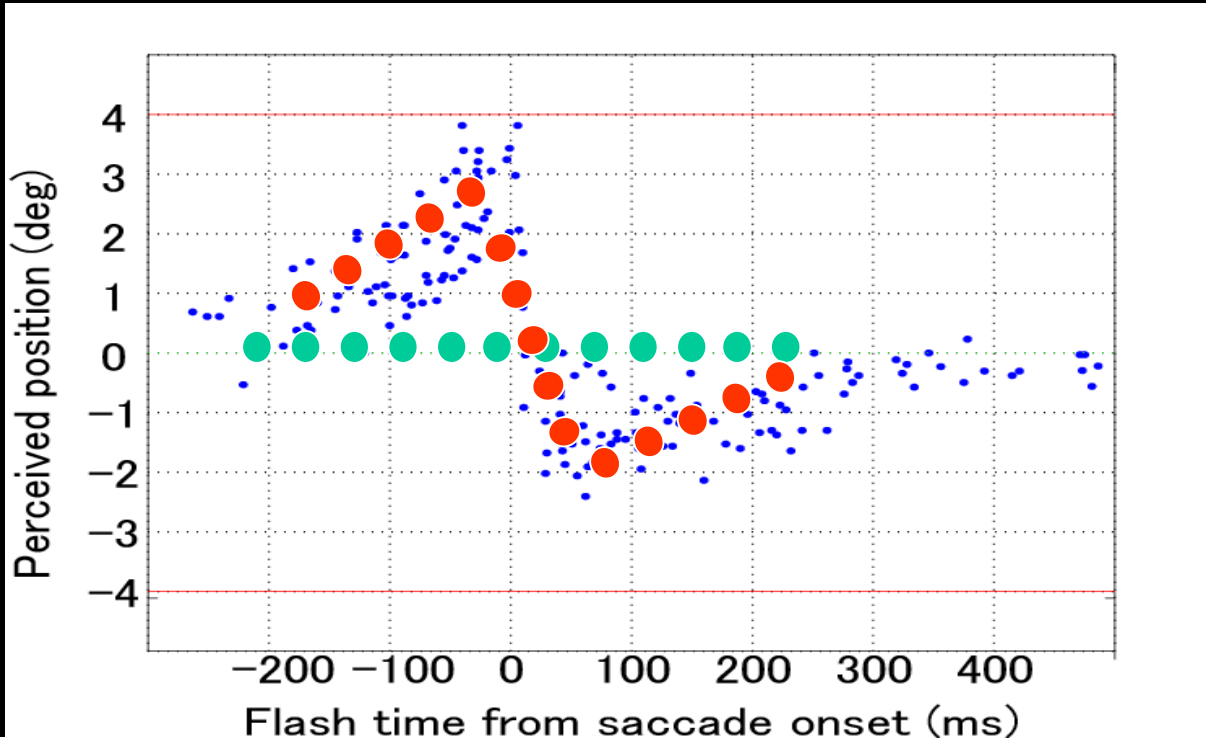
In fact, under certain conditions, the perisaccadic mislocalizations of a single flash do not agree with those of less transient stimuli.

* Continuous lights : Schlag et al. 1995, Cai et al. 1997
* Successively-presented two flashes: Sogo & Osaka 2001

First question

Does the mislocalization of a single flash
indicate a general failure of perisaccadic space constancy ?

Can the percept of continuous light (a 500Hz flicker) be predicted by the time course of localization for a single flash?



Our answer

No

Second question

In our environment, almost every object continues to exist before and after the saccade.

How does the visual system realize perisaccadic space constancy for continuous stimuli?

To answer this question,
we investigated the percept for 500 Hz flickers
presented at around the time of the saccade,
by systematically changing the time of onset or offset
of the flicker.

Our answer

Two-stage localization process

1. Generating spatial configurations
   based on the retinal image
2. Localizing each configuration as a whole
   based on the eye position signal
   sampled at a time temporally
   distant from the saccade

Experiment: 3 conditions

Single flash condition

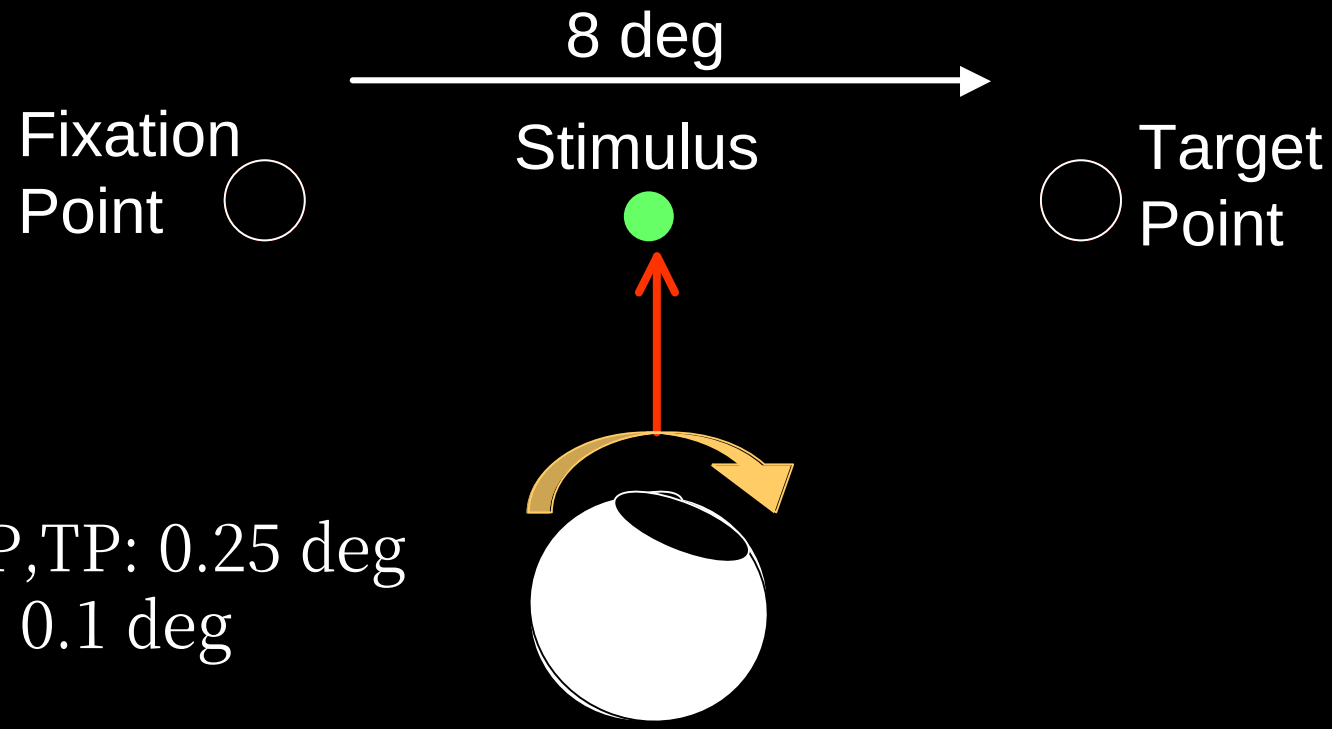
Flicker offset-variable condition

Flicker onset-variable condition

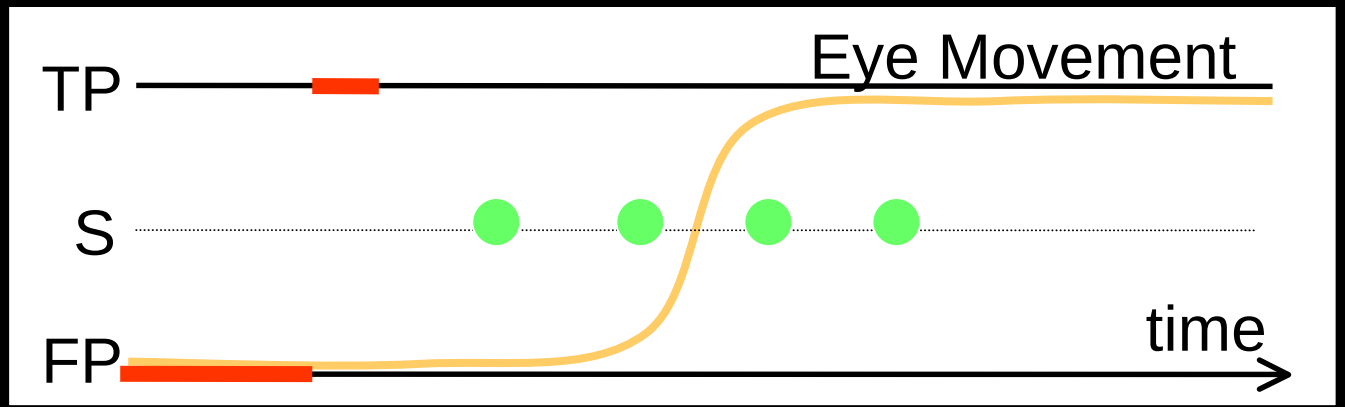
Methods (1)

In completely dark room

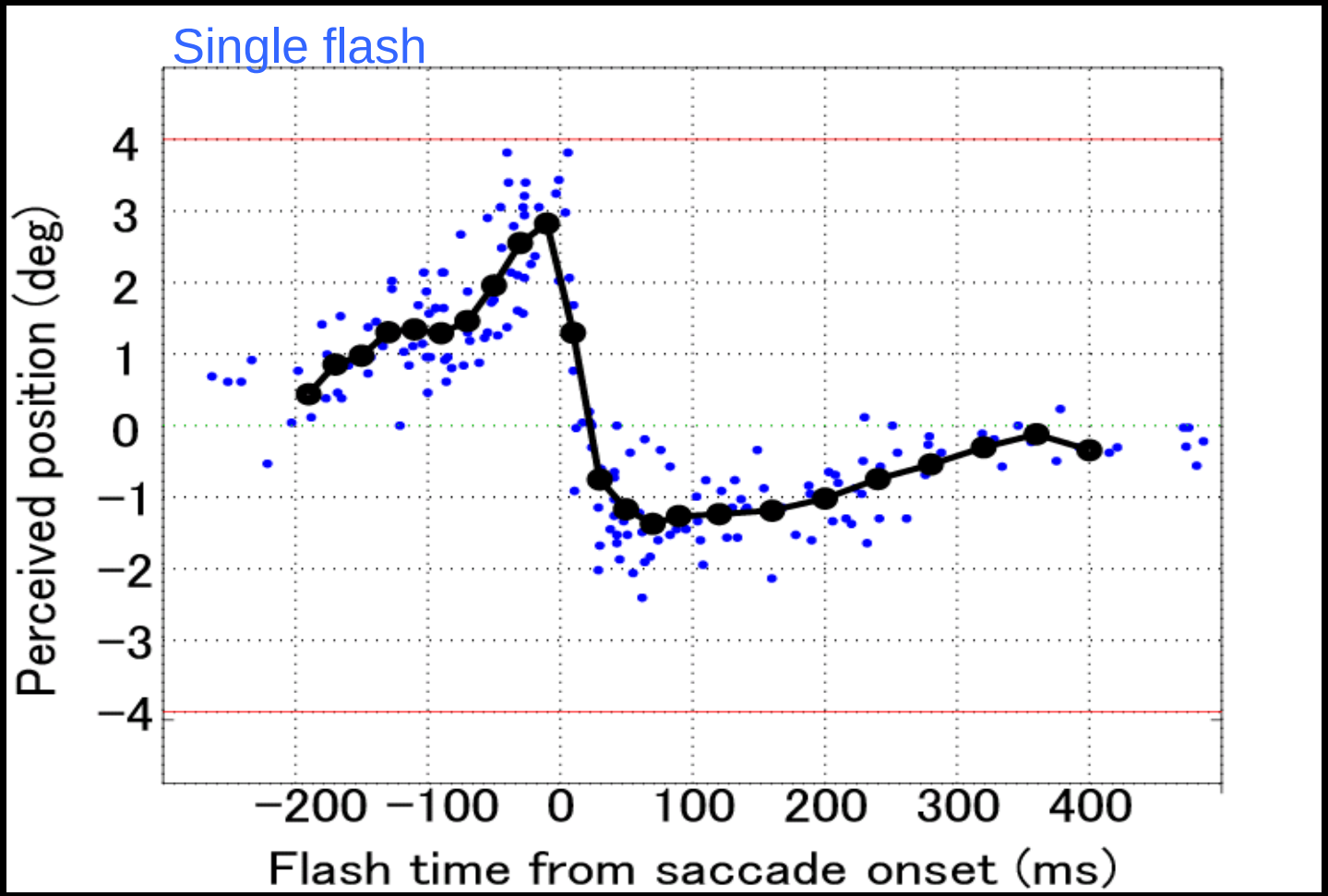
Single flash condition
(following, e.g., Honda 1990)



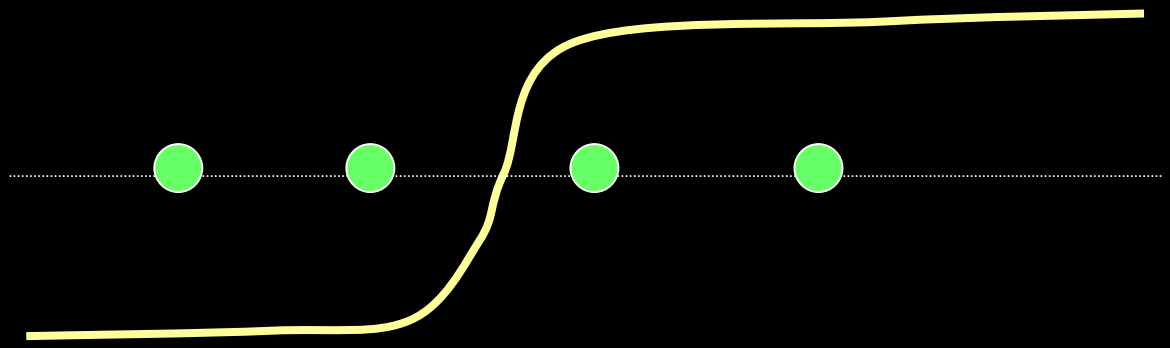
FP,TP: 0.25 deg
S: 0.1 deg



Result1
Single
Flash

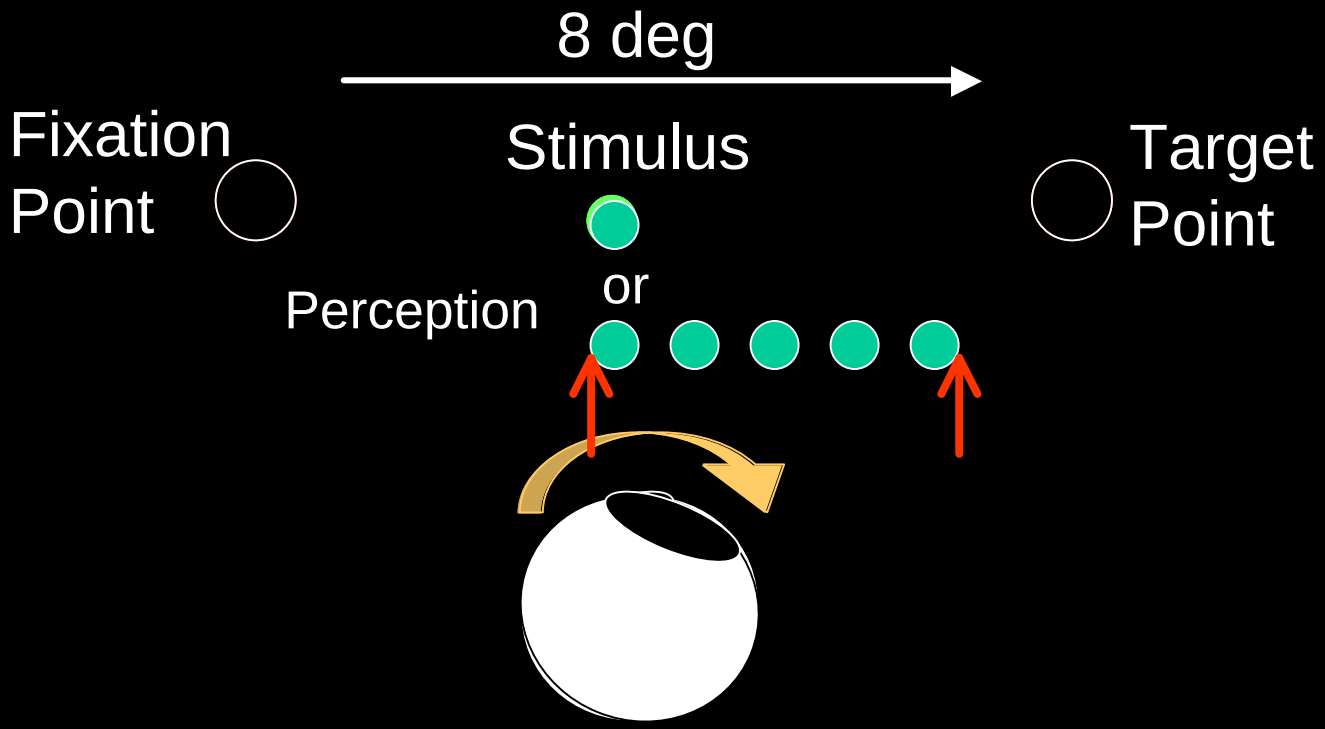


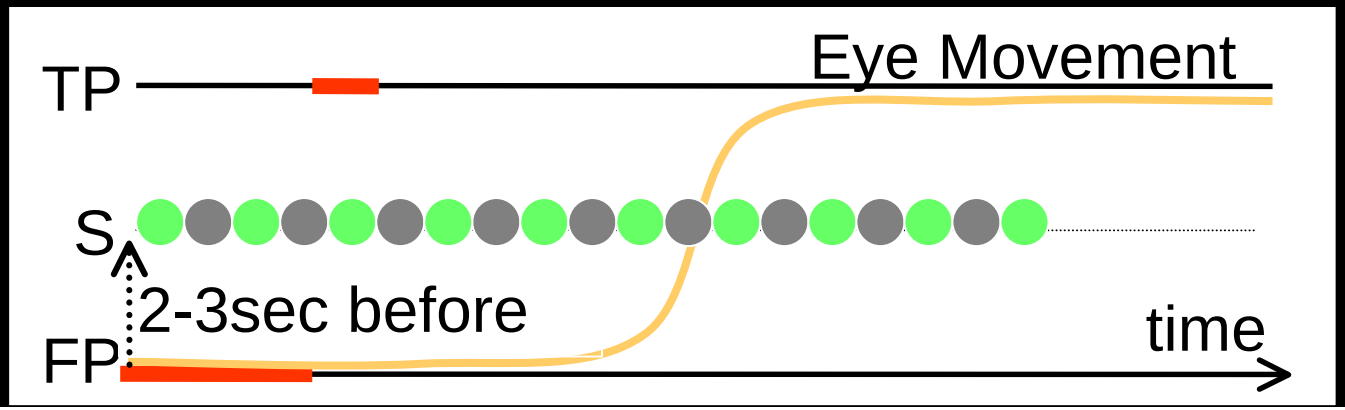
Flash
Stimulus



Methods (2)

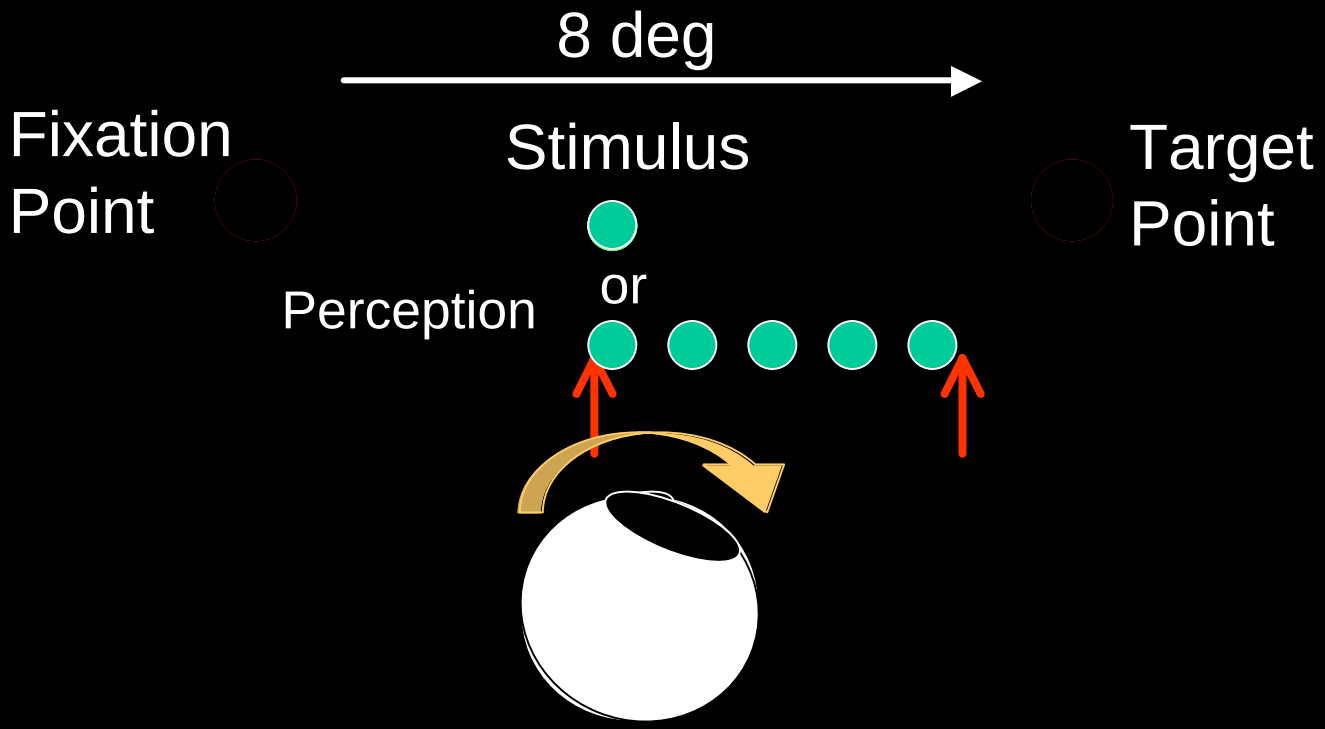
Offset-variable condition
Onset-variable condition

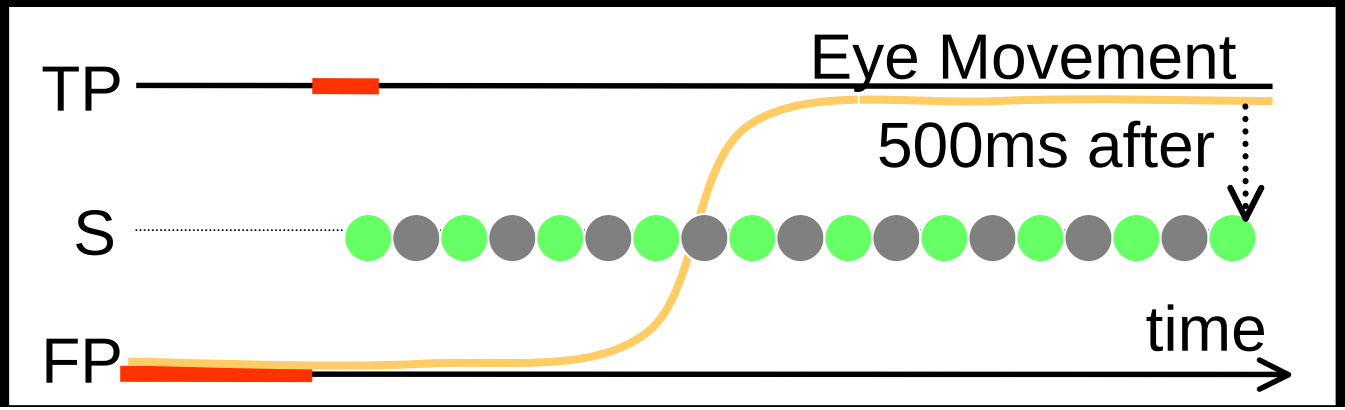




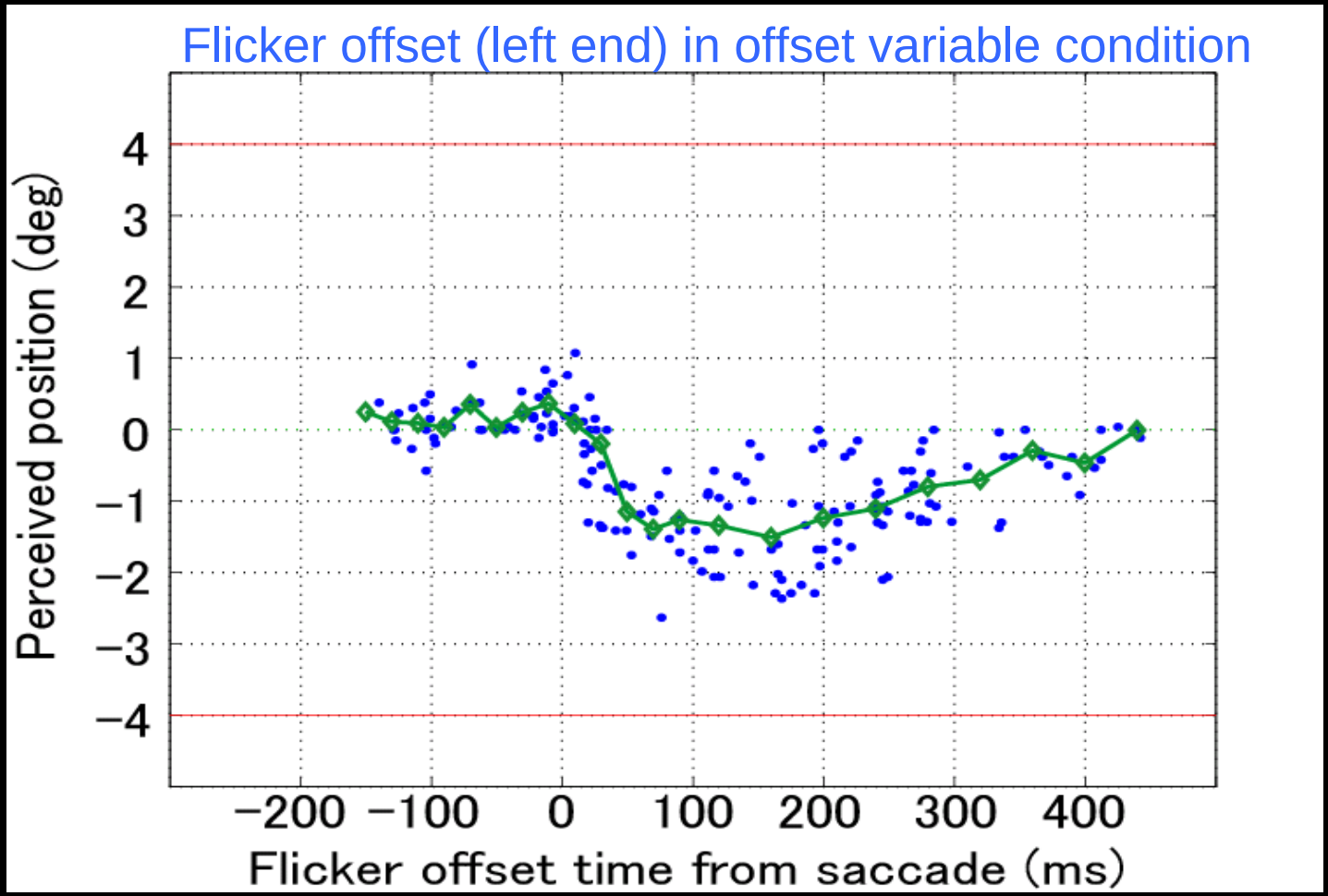
Methods (2)

Offset-variable condition
Onset-variable condition

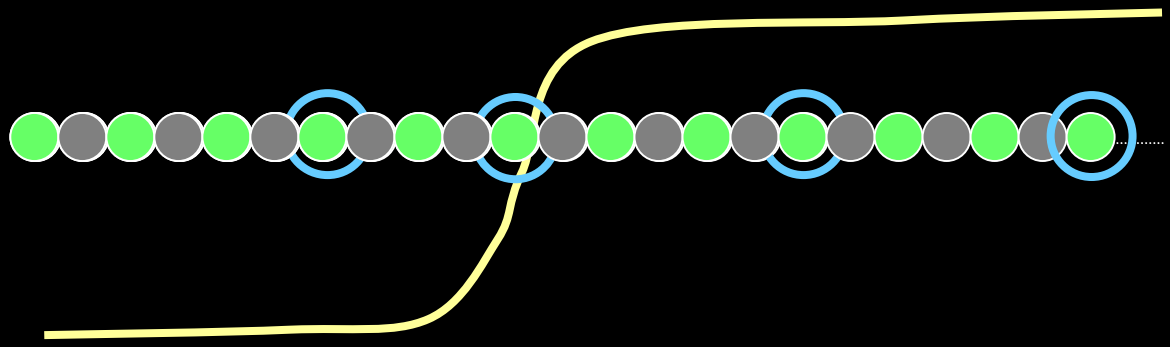




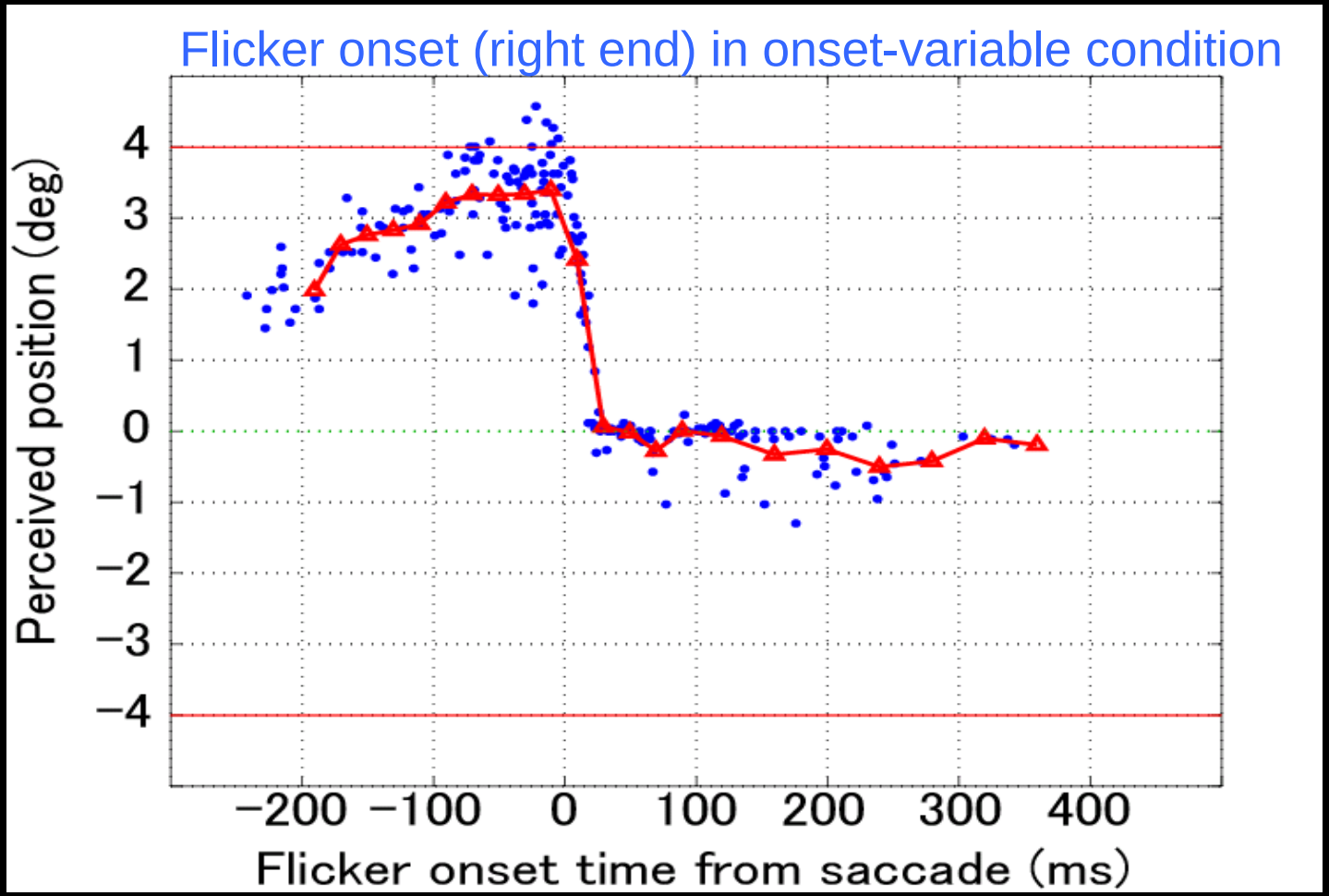
Result2
Offset-
Variable



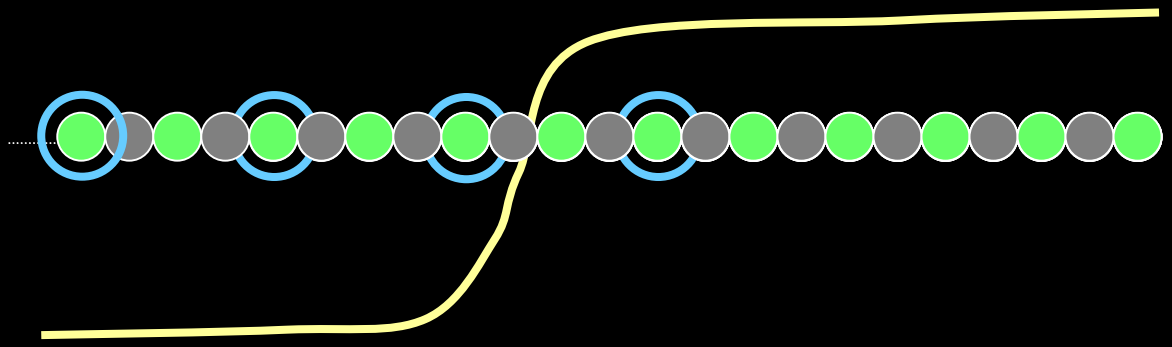
Flickering
Stimulus



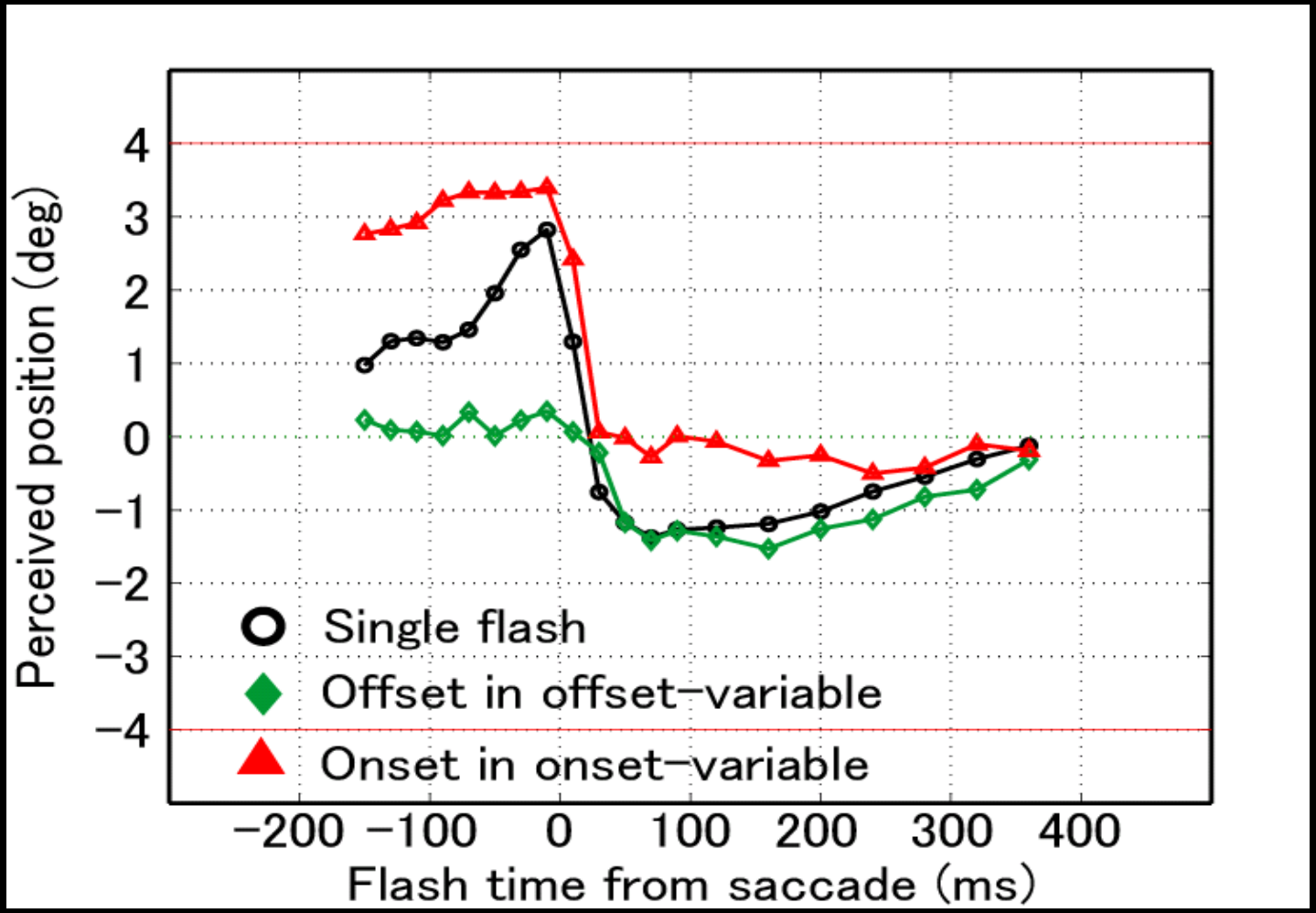
Result3
Onset-
Variable



Flickering
Stimulus

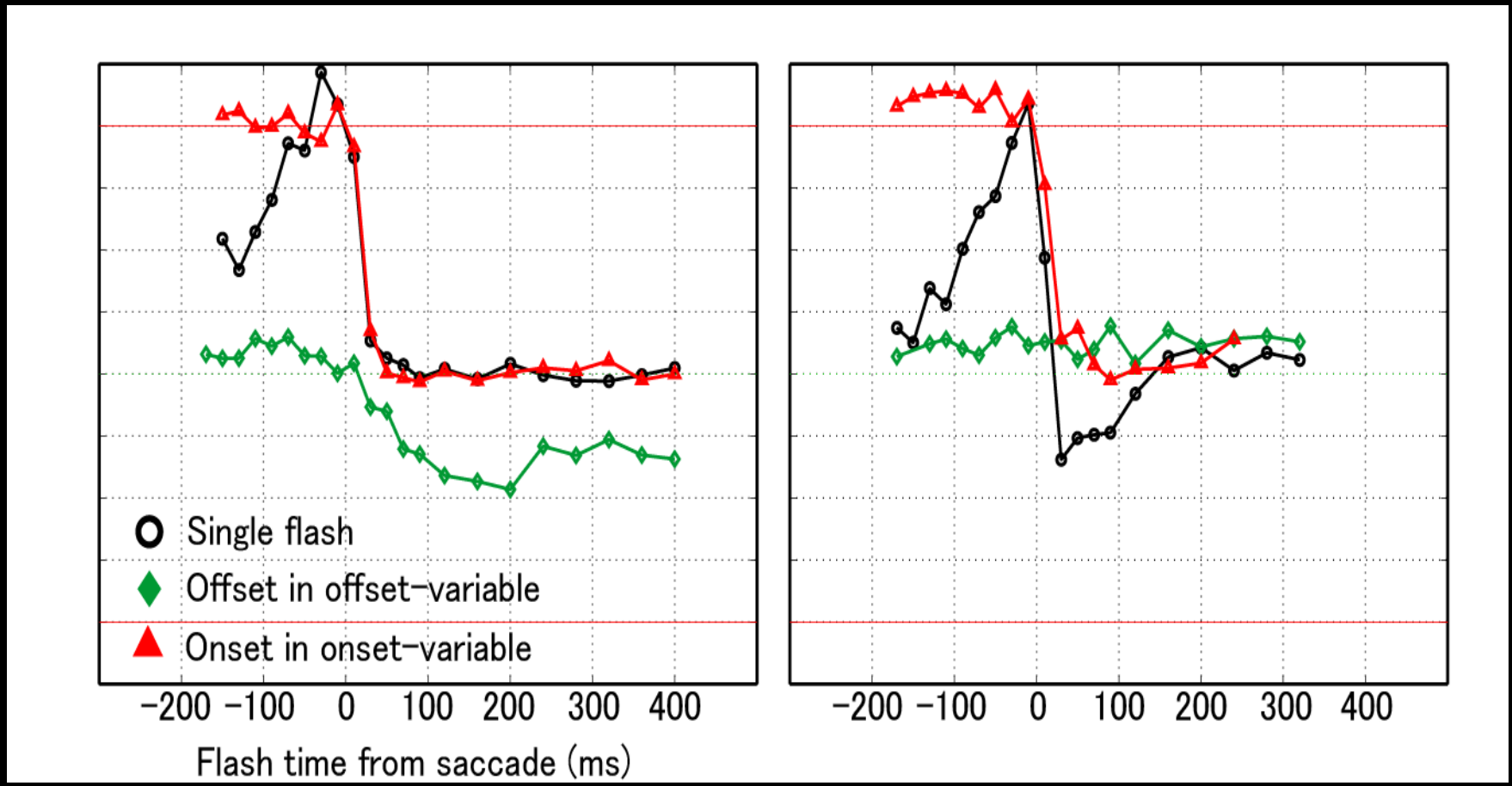


Dissociation of perceived positions



These flashes are localized at different positions, even though they are presented at the same timing and at the same position on the retina.

Other Subjects



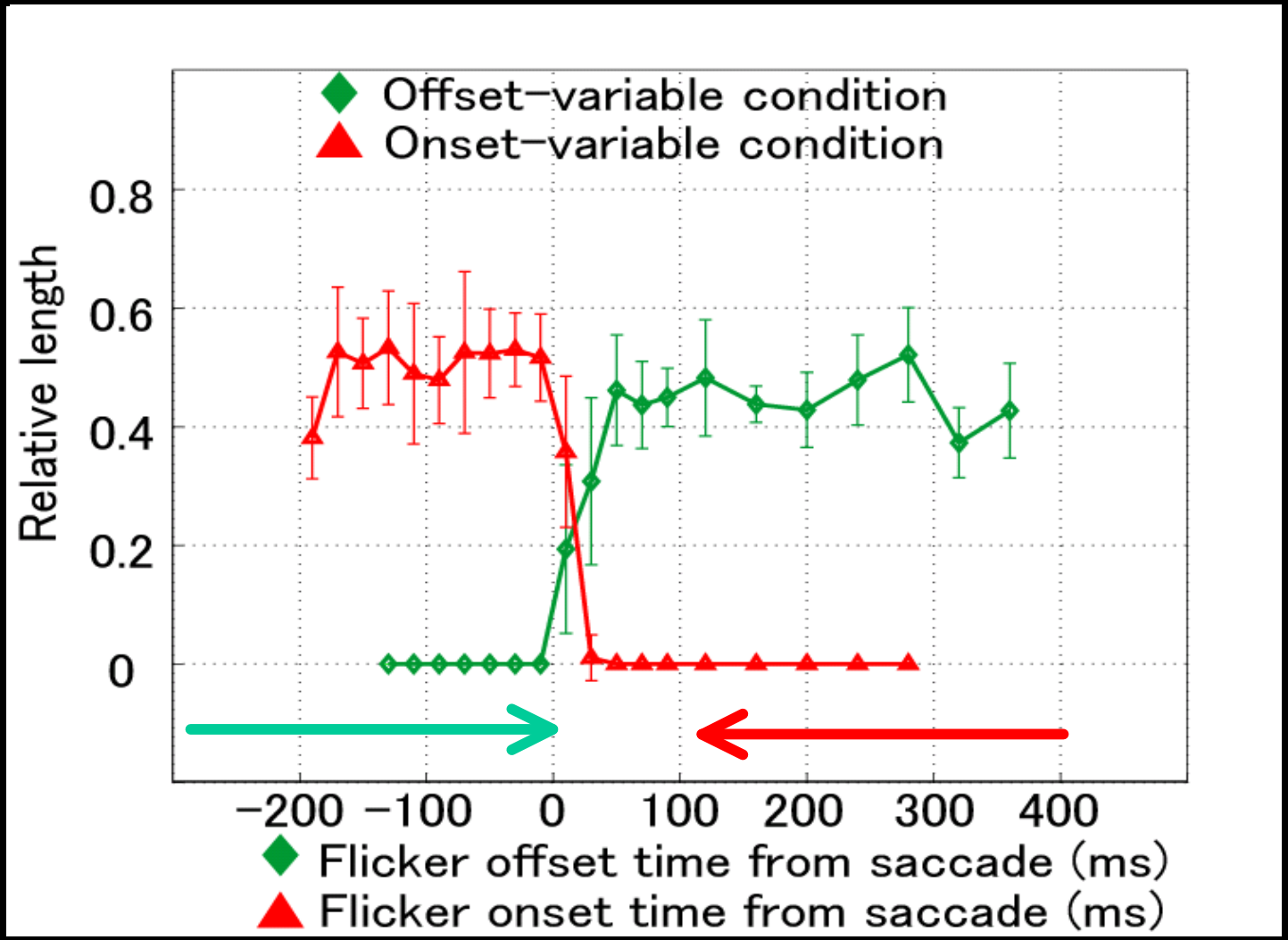
First question

Can the percept of continuous light (a 500Hz flicker) be predicted by the localization for a single flash?

Answer

The time course of perisaccadic localization for a single flash cannot predict the perceived position of perisaccadic flickers.

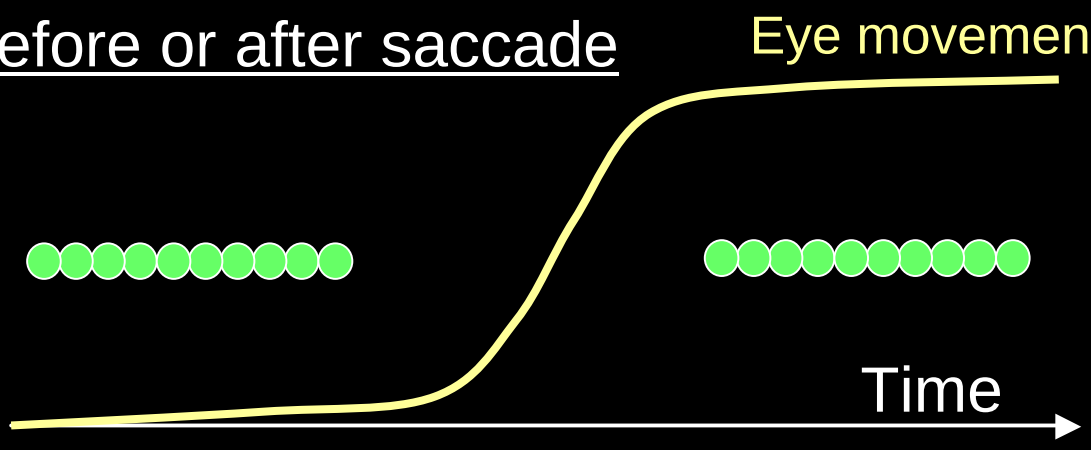
Perceived length relative to the saccade amplitude



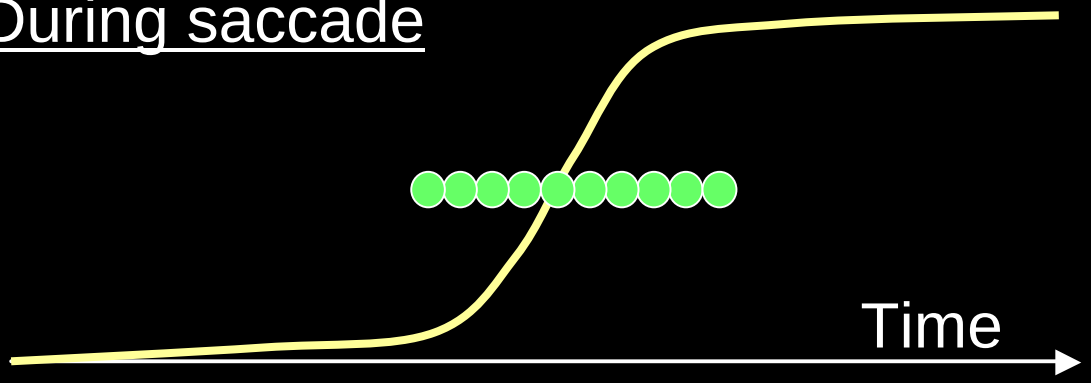
What does this data imply ?

Spatial configuration

Before or after saccade



During saccade



Configuration based on retinal information

Single dot

Dot array

This means that perceived stimulus configuration is almost consistent with retinal images.

Second question

How to localize continuous stimuli presented at around the time of a saccade?

Hypothesis

Two-stage localization

1, Spatial configuration (dot or dot array)

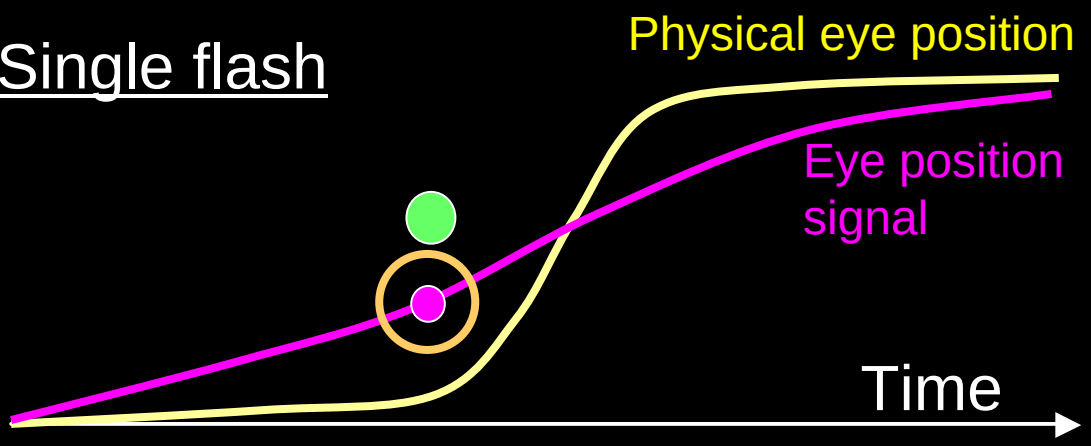
2, Localization of each configuration as a whole

However, given the eye position signal changes overtime, which eye position signal is used for localization?

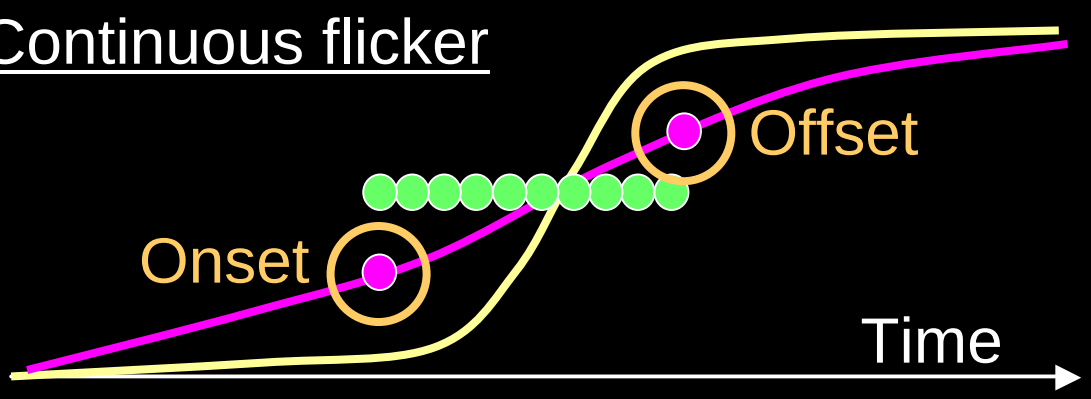
Stage 2: Localization of configuration as a whole

If the eye position signal for a single flash is sampled at the time of flash presentation, it's possible that the eye position signal for a continuous flicker is also sampled at a transient event such as an onset or offset of the flicker.

Single flash



Continuous flicker



Localization cue

Flash presentation time

Transient event

Onset ?
or
Offset ?

Stage 2: Models

1, Onset–based localization (Schlag et al. 1995)
using eye position signal at flicker onset

$$X_{onset}(t_1,t_2) = X_{flash}(t_1)$$

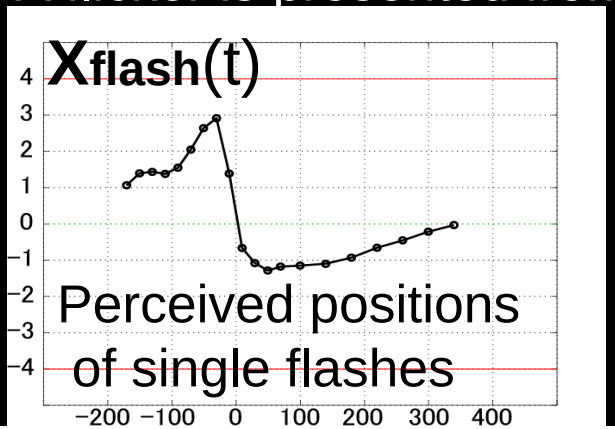
$$X_{offset}(t_1,t_2) = X_{flash}(t_1) - L(t_1,t_2)$$

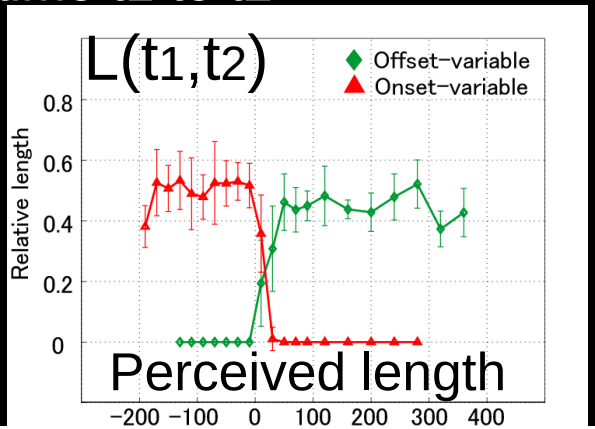
2, Offset–based localization
using eye position signal at flicker offset

$$X_{onset}(t_1,t_2) = X_{flash}(t_2) + L(t_1,t_2)$$

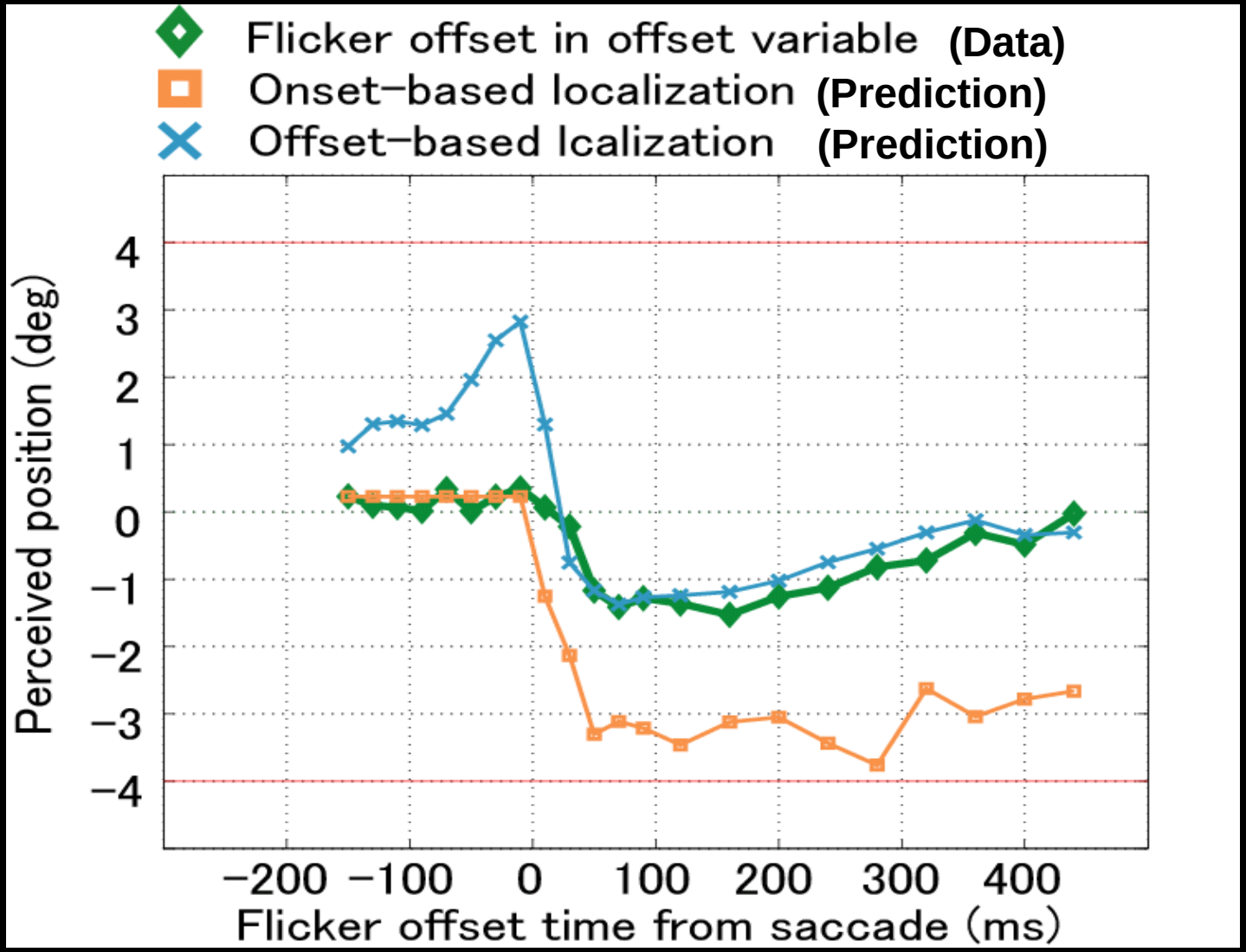
$$X_{offset}(t_1,t_2) = X_{flash}(t_2)$$

A flicker is presented from time t1 to t2



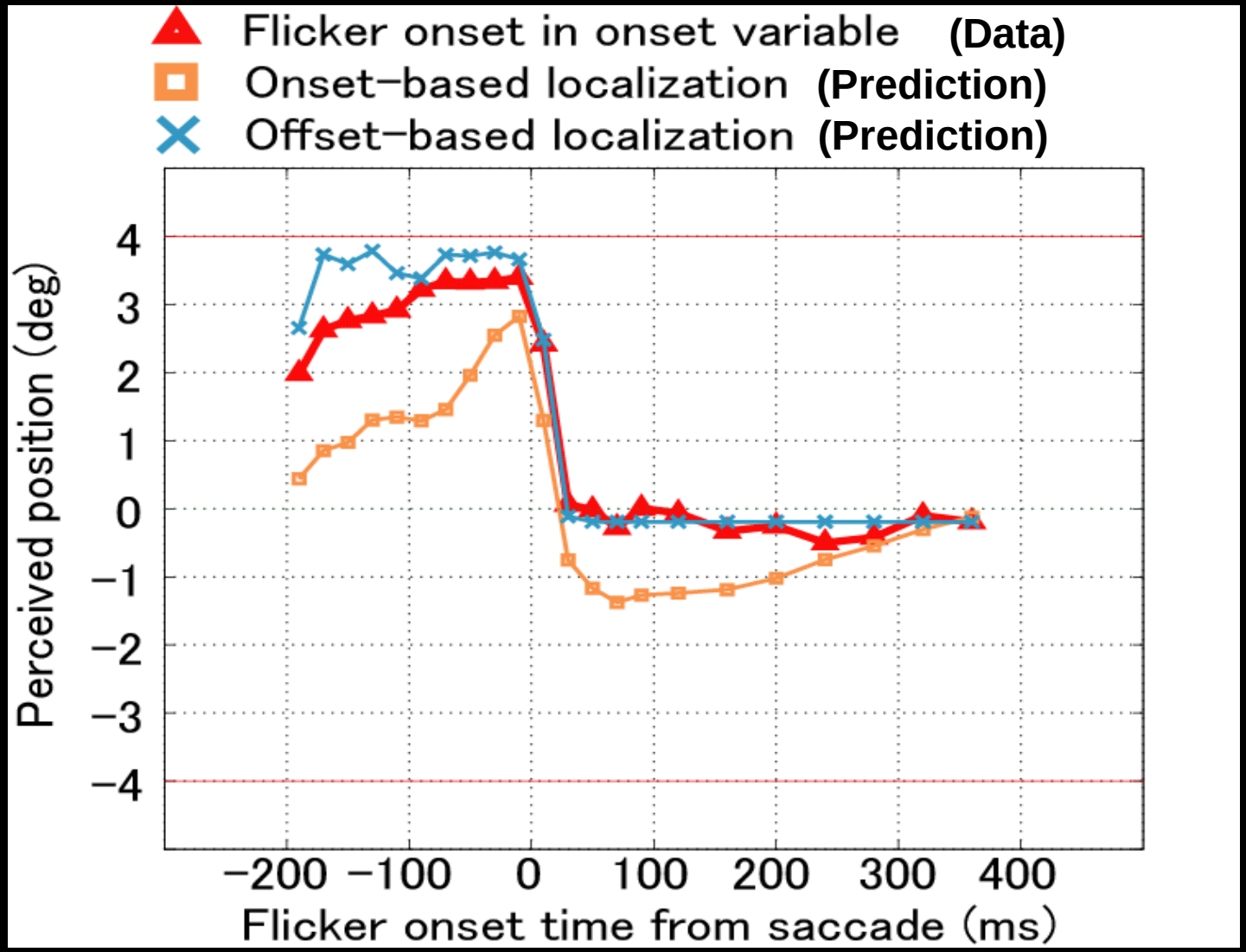


Offset-variable



Before the saccade, the flicker offsets coincide with the prediction of the onset-based localization.
After the saccade, the flicker offsets coincide with the prediction of offset-based localization.

Onset-variable

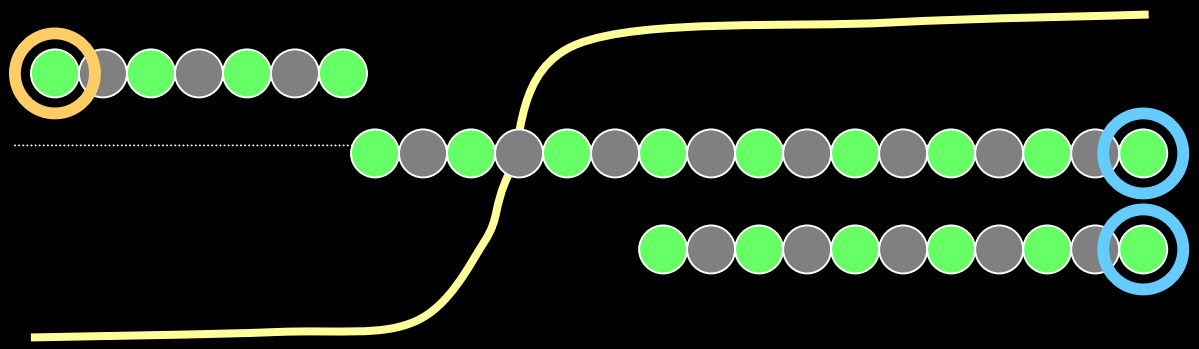


For all timings, the flicker onsets coincide with the prediction of the offset-based localization.

Summary

Flickers ending before the saccade,
the perceived position can be predicted by
onset-based localization.

Flickers ending after the saccade,
the perceived position can be predicted by
offset-based localization.



In either case, the eye position signal is sampled
at a time temporally distant from the saccade.

Conclusion

1) Does mislocalization of briefly flashed stimuli indicate a general failure of space constancy around the time of the saccade? ==> No

2) How to localize continuous stimuli presented at around the time of the saccade?

==> Two-stage localization process

1. Generating spatial configurations
   based on the retinal image
2. Localizing each configuration as a whole
   based on the eye position signal sampled at a time temporally distant from the saccade

This may help perisaccadic precise localization and space constancy in continuous environment.

Thank you very much.